Indian Journal of Orthopaedics (2021) 55:1277–1285
https://doi.org/10.1007/s43465-021-00538-8

ORIGINAL ARTICLE

A New Type of Periprosthetic Fracture: Is It the Time to Update the Unified Classification System?

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Received: 11 June 2021 / Accepted: 27 September 2021 / Published online: 3 October 2021

Abstract

Introduction Increased number of primary and revision arthroplasties performed globally has led to a surge in the numbers of periprosthetic fractures. The Unified Classification System (UCS) advocated a rational approach towards the classification of periprosthetic fractures. We present here an update to the UCS with addition of new fracture pattern encountered in orthopedic practice.

Methods A retrospective study was conducted to review the service arthroplasty register for the cases with unique fracture pattern where the periprosthetic fracture around total hip arthroplasty was also associated with fracture of the prosthetic component. The details were retrieved from the medical record and the patients were called for a review. The radiological assessment was done with X-rays and clinical assessment with Harris Hip Scores at the latest follow-up.

Results Between 2012 and 2019, 11 patients (7 males and 4 females) were operated for peri-prosthetic fracture with a unique pattern where the fracture of femur was associated with fracture of the femoral stem as well. The mean age of the patient at the time of fracture was 56.8 years (range 42–71 years). All patients were managed with revision hip surgery. One patient died due to malignancy after 7 years of revision surgery. All the surviving patients are doing well with a mean Harris Hip Score of 86.8 at the latest follow-up of 2–9 years (mean 5.0 years).

Conclusion With emergence of this new fracture pattern, it is recognition as a separate entity would help in better understanding and augmentation of the existing classification system of periprosthetic fractures.

Keywords Periprosthetic fracture · Unified Classification System · G-type

Introduction

The number of total joint replacements for end stage arthritis is on the rise. The projection models have anticipated that the numbers of primary total hip arthroplasty (THA), and primary total knee arthroplasty (TKA) are expected to grow by 71% and 85%, respectively, by the year 2030 in United States alone [1]. The projected burden of THA and TKA in Australia is estimated to rise by 208% and 276%, respectively during the same period [2]. With this increment in numbers, the incidence of periprosthetic fractures is bound to increase. Also, new patterns of periprosthetic fracture may emerge.

Sporadically seen implant fractures after total hip arthroplasty (THA) have been reported in the literature since 1975 starting with the Charnley's prosthesis [3–8]. However, they were fractures of the implants alone attributed to poor cementing or poor metallurgy of the initial designs. Fractures of the cementless femoral stems have also been reported but are limited to case reports and small case series attributed to good fixation distally with poor osseous support proximally, or, through a preexisting ununited fracture [9, 10]. The newer generation implants have been reported to fracture at the trunnion or the stem-neck junction as consequences of trunnionosis or faulty designs [11–16]. Also, while fractures of the femoral stem along with fracture of femur have been reported in a small series [10], no attempts were made to identify them as a distinct pattern as they did

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not fit in the existing classification system [17], and, predated the currently popular Universal Classification [18].

We present a small series of unusual fractures through the femoral shaft and the femoral prosthesis and attempt to assimilate it in the currently popular Universal classification system. We also discuss the technique of removal of the broken implants and subsequent management.

Methods

The service arthroplasty records of all the consecutive patients with periprosthetic fractures following hip arthroplasty in our tertiary care centre were retrospectively reviewed after obtaining the ethical clearance from the Institute Ethics Committee. Only the cases of peri-prosthetic fracture with a unique pattern where the fracture of femur was associated with fracture of the femoral stem as well i.e., fracture line traversing the prosthesis within, were included in the study. Patients with fracture of the femoral prosthesis alone without femoral shaft fracture were excluded from the study. Eleven patients were eligible for inclusion. The details of all these patients were retrieved from the medical records. Owing to the COVID pandemic, the patients were first assessed through telemedicine via video conference [19, 20]. To ensure minimum contact, the literate patients were asked to carry the recent radiographs from the nearby imaging centre or e mail the soft copies to the senior author. All the patients were called for review with prior staggered appointments over a period of 2 weeks. The radiological assessment was done with antero-posterior and lateral radiographs and clinical assessment with Harris Hip Score [21]. Health safety measure were strictly followed during clinical assessment of the patient.

Results

Between 2012 and 2019, 11 patients (7 males and 4 females) with femoral peri-prosthetic fracture around the THA had been operated where the fracture was associated with fracture of stem as well. The mean age of the patient at the time of fracture was 56.8 years (range 42–71 years). There were two females with history of rheumatoid arthritis. All of them presented with a history of trauma. Four of them had a low velocity trauma and seven with a history of high-velocity trauma. All patients had undergone successful revision hip surgery. The demographic details along with the surgical details including management technique and follow-up are mentioned in Table 1. One patient died due to malignancy after 7 years of revision surgery. All the surviving patients are doing well at the latest follow-up of 2–9 years (mean 5.0 years). All the fractures had united. All except one were devoid of any radiological signs suggesting loosening or failure of either of the femoral stem or the acetabular component. One patient had non progressive lucencies less than 2 mm around the proximal femur in Gruen zones 1, 2 and 7. The clinical outcome of the surviving patients was good with a mean HHS of 86.8 at the latest follow-up.

Case Examples

Case 1. A 66-year-old lady presented with periprosthetic femoral fracture with mid-stem fracture of insitu Austin Moore Prosthesis done 11 years back for fracture neck of femur (Fig. 1A). The proximal prosthetic fragment was removed by disrupting the implant bone interface using a reciprocating saw and reverse hitting the prosthesis subsequently. The distal fragment was removed after disrupting the prosthesis-bone interface by multiple drilling with K-wires and use of trephine reamer. As both the proximal and distal fragments had good bone, revision surgery was done with modular stem prosthesis and cemented cup (Fig. 1B).

Case 2. A 70-year-old female had undergone revision hip arthroplasty for a periprosthetic fracture femur (Type B2) using a fully porous coated cylindrical stem 10 years back. She sustained with femoral shaft and mid-stem fracture following fall from height (Fig. 2A). The proximal prosthetic fragment removal necessitated osteotomy as all the other attempts at removal were unsuccessful. There was still good bone stock distally; hence, the revision surgery was performed with a long revision interlocking stem supplemented with circumferential struts (Fig. 2B). The acetabular component, which was well fixed from the index surgery, was retained.

Case 3. A 55-year-old female underwent primary total hip arthroplasty with a long cylindrical stem for failed osteosynthesis of proximal femoral fracture. She presented with femoral shaft with mid-stem fracture following trauma (Fig. 3A). There was massive bone loss from the proximal femur, which eased the removal of proximal fragment. The distal fragment of the broken prosthesis was removed with trephine reamer. Considering the age of the patient, revision surgery was performed using proximal femoral allograft prosthesis composite (Fig. 3B). As she was osteoporotic, the construct was augmented with struts around the APC-host bone junction. The acetabular component was well fixed without any poly wear and hence was retained.

Principles of Treatment

In the majority of periprosthetic fractures, the surgeon can decide whether to choose osteosynthesis or revision replacement depending upon the fracture type. However, there is no description of the above mentioned pattern even in the

Table 1 Demographics and medical details of the patient with periprosthetic fracture having unique pattern with their follow-up score

Name initials	Age (years)/ gender	Fractured implant design	Duration since index surgery	Removal technique	Revision technique	(Year of surgery) Follow-up (years)	HHS
L. J	68/F	Uncemented fully coated cylindrical stem	6 years	Proximal fragment: ETO Distal fragment: multiple K-wires + trephines	Distal locking long revision stem supplemented with strut allografts	(2012) 9 years	90
S. S	55/F	Uncemented fully coated long cylindrical stem	3 years	Proximal fragment: loose, removed with ease Distal fragment: multiple K-wires + trephines	Allograft prosthesis composite supplemented with strut allografts	(2013) 8 years	84
J. A	66/F	AMP	11 years	Proximal fragment: reciprocating saw + reverse hitting Distal fragment: vise grip pliers	Revision Modular stem prosthesis	Died after 7 years of revision surgery due to malignancy	–
D.S	52/M	Bipolar stem	4 years	Proximal fragment: reverse hitting Distal fragment: multiple K-wires + trephines	Long cylindrical stem	(2014) 7 years	92
A.R	44/M	Cemented long stem	6 years	Proximal fragment: excised Distal fragment: multiple K- wires + trephine	Allograft prosthesis composite supplemented with strut allografts	(2014) 7 years	90
S. B	70/F	Uncemented fully coated long cylindrical stem	10 years	Proximal fragment: ETO Distal fragment: multiple K-wires + trephine	Distally locking long HA coated stem	(2016) 5 years	80
B. S	50/M	Uncemented fully coated long cylindrical stem	8 years	Proximal fragment: multiple K wires + episiotomy + proximal slap hammering of vise grip plier Distal fragment: multiple K-wires + trephines	Revision long cylindrical stem	(2017) 4 years	88
S. P	42/M	Uncemented fully coated cylindrical stem	4 years	Proximal fragment: loose, removed with ease Distal fragment: multiple K-wires + trephines	Long conical stem	(2018) 3 years	90
H.S	62/M	Bipolar stem	5 years	Proximal fragment: ETO Distal fragment: multiple K-wires + trephines	Long cylindrical stem	(2018) 3 years	86
A.K. G	55/M	Uncemented fully coated long cylindrical stem	4 years	Proximal fragment: loose, removed with ease Distal fragment: multiple K-wires + trephines	Long conical stem	(2019) 2 years	86

Table 1 (continued)

Name initials	Age (years)/ gender	Fractured implant design	Duration since index surgery	Removal technique	Revision technique	(Year of surgery) Follow-up (years)	HHS
M.D	61/M	Cemented long stem	10 years	Proximal fragment: loose with poor bone stock Distal fragment: multiple K-wires + trephines	Allograft prosthesis composite	(2019) 2 years	82

M male, *F* female, *AMP* Austin Moore prosthesis, *ETO* extended trochanteric osteotomy, *HA* hydroxyapatite

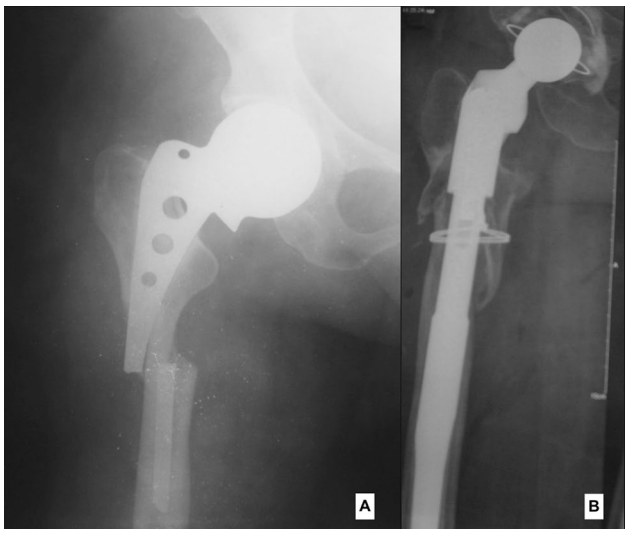

Fig. 1 **A** and **B** Radiograph showing periprosthetic femoral fracture with fracture of Austin Moore Prosthesis (**A**). Revision surgery was performed with a modular stem (**B**)

most widely accepted classification [17]. Nevertheless, all these fractures with unique pattern as described above need a revision replacement surgery. The choice of reconstruction procedure to be performed depends on the following factors:

(a) How easily the fractured implants can be removed?
(b) Status of the remaining host bone stock after implant removal
(c) Age of the patient and activity level

However, the removal of fractured implants especially the distal fragment is quite challenging. The proximal implant fragment can be removed using an extractor with a slap hammer or by reverse hitting the fractured end of implant and removing from the proximal end of femur. Success depends on the extent of the integration of the implant with the bone. The removal of cemented prosthesis or a loose uncemented proximal prosthetic fragment generally does not present a difficulty. However, the well-fixed uncemented implants may pose a stiff challenge. One may even require an osteotomy to remove the implant. This also depends on the quality of the remaining bone which helps decide if it is worth preserving the bone while removing the fractured prosthesis or sacrifice the whole proximal fragment as in an elderly low demand patient with severely compromised bone quality.

The authors recommend a stepwise protocol while removing the integrated fractured implant fragment:

First, expose the fracture site and try hitting the fracture end of the prosthesis with a punch smaller or equal to the diameter of the prosthesis followed by removal of the fragment through the proximal end of the femur by holding it with a grasper. Frequently, femoral stems are provided with a hole or threads for screw hold mechanism at the shoulder, which eases its removal by engaging the dedicated removal instrument with slap hammer in it. If it cannot be removed, pass K-wires multiple times around the implant to disrupt the implant-bone interface. This can be followed by passing a small saw blade mounted on a reciprocating saw along and around the implant depending on the shape of the implant. If it still cannot be removed, the authors recommend cortical episiotomy i.e., a linear vertical osteotomy of the bone along the length of the implant inside it. If it still doesn't move then one may have to go for extended procedure using osteotomy to split the bone into two halves and remove the implant from the canal.

The distal implant fragment presents a big challenge because the reconstruction option largely depends on the residual host bone stock following removal of the prosthetic fragments. It depends on the design of the implant. If the fractured implant is proud over the bone end of the distal bony fragment allowing it to be held by a vise grip plier with slap hammer, the distal fragment may possibly be removed. However, the osseointegrated implants may require additional procedure as mentioned above to sever the implant from the bone. In case of cylindrical prosthesis, the authors recommend the use of successive trephine reamers starting from the size 1 mm larger than the diameter of the cylindrical prosthesis (Fig. 4A). This can also be preceded by the use of multiple K-wires and/or saw as described above for the proximal fragment (Fig. 4B). If the fracture end does not allow holding the in situ implant

Fig. 2 **A** and **B** Radiograph showing periprosthetic femoral fracture with fracture of a cementless fully porous coated cylindrical stem (**A**). Revision surgery was performed with a long revision interlocking stem supplemented with circumferential struts (**B**)

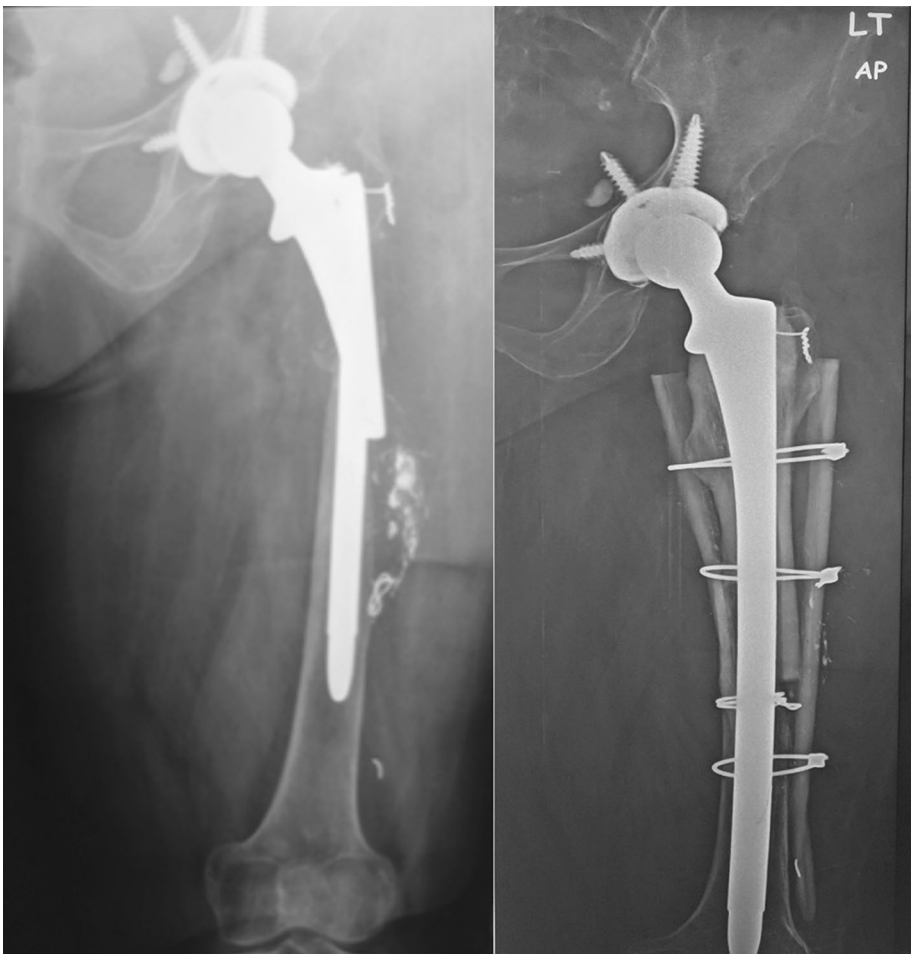

Fig. 3 **A** and **B** Radiograph showing periprosthetic femoral fracture with fracture of a cementless fully porous coated cylindrical stem (**A**). Revision surgery was performed with a allograft prosthesis composite and supplemented with circumferential struts (**B**)

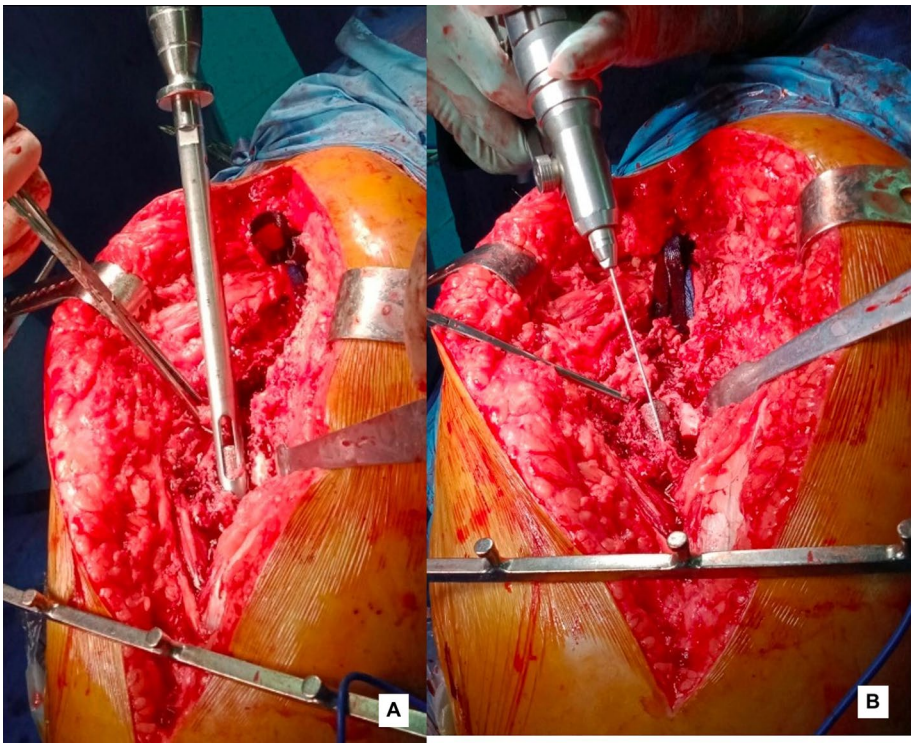

Fig. 4 **A** and **B** Intraoperative picture showing use of a trephine reamer of size 1 mm larger than the diameter of the distal fractured stem (**A**). K-wires can be passed along the implant to disrupt the implant bone interface (**B**)

readily one may have to sacrifice a little segment of bone from the fractured end. In case the above procedure is not applicable or fails to move the implant, one can make a small window just distal to the tip of the implant and reverse hit the implant to remove it from the fracture site. William Harris described extraction of the broken stem using the Midas Rex extraction system [22]. A hole is drilled over the exposed upper surface of the distal broken stem followed by a side cutting drill to create an undercut in the metal (Fig. 5). The extractor that fits into this undercut is locked into position and, in turn, is attached to a cannulated T-handle and then to a slap hammer to extract the broken stem. The advantage with this technique is that neither a window nor the osteotomy is necessary. The distal cement column can be left intact. An uncemented stem can also be removed after disintegrating it from the bone. If all these procedures fail, one has to opt for osteotomy as for the proximal fragment. Apart from this, there are different extraction techniques particularly the removal of distal fragment, described individually in the literature in the cases with fracture of the femoral stem alone on a cases to case basis [23–26]. The authors also believe that the technique of removal depends on the individual case to case and the availability of the final reconstruction option depends on the remaining bone stock and the age of the patient [27]. The authors' recommended treatment options in different scenarios are mentioned in Table 2.

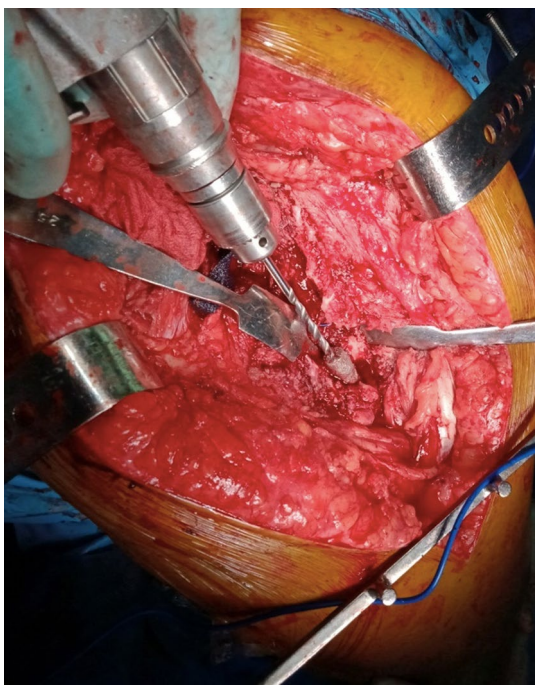

Fig. 5 Intraoperative picture showing drilling of the exposed upper surface of the distal fragment

Table 2 Authors recommended treatment options in different scenarios for G-type periprosthetic fractures

Scenario	Treatment option
1. Good bone stock in both the fragments	Revision joint arthroplasty
2. Poor bone stock in the fragment close to the joint	Young patient: allograft prosthesis composite Elderly patient: megaprosthesis
3. Poor bone stock in both the proximal and distal fragments	Adequate remaining bone stock in young patient: allograft prosthesis composite with or without struts augmentation Adequate remaining bone stock in elderly: megaprosthesis Remaining bone stock not adequate to hold the allograft prosthesis composite or megaprosthesis: total femoral prosthesis

Discussion

Periprosthetic fractures with concomitant fracture of the prosthesis following total joint arthroplasty are either unreported or underreported. We observed all such cases after total hip arthroplasties. Fractures of the femoral stem alone have been reported and discussed in the literature. Most of such fractures are attributed to the compromised proximal osseous support in the face of a distally osseointegrated femoral stem. Prosthetic fracture and loosening are interrelated, as the fracture generally occurs due to loosening with loss of osseous support around the implant [8]. Lakstein et al. [28] in their series of mid stem fracture following revision hip arthroplasty suggested that the predisposing factors responsible for these uncommon fractures are overweight, high physical activity, deficient osseous support, loosening or malpositioning, presence of stress riser and reduced cross sectional area within the stem. This may also occur in the acute setting following a trauma. The authors believe that the mechanism of fracture was not different from others i.e. trauma to a distally well fixed stem in the face of loose stem proximally. However, there were four cases where the proximal fragment was also well fixed warranting an extended trochanteric osteotomy for its removal suggesting the trauma causing fracture of bone through and including the intramedullary implant was the plausible cause.

Duncan and Haddad [18] advocated the Unified Classification System (UCS) and incorporated different patterns of fracture that were not included in the previous classification systems. The UCS found a place in the algorithms of patient care, and allowed consistency in the reporting of periprosthetic fractures in registries. It served a useful purpose in the management and outcome of these complicated fractures. We surmise that this pattern of fracture be identified and classified as a different entity in the existing Unified Classification System as **G type** fracture. This pattern be better explained as the fracture line passing across one cortex to the opposite cortex along with the fracture of the implant within the medullary canal. The type **'G'** is to mean **'Going across the implant' and** is given to assist with recall and follow the mnemonic given by Duncan and Haddad following the other fracture types, A to F [18].

The purpose of classifying this pattern of fracture into a separate group is to highlight its occurrence in orthopedic practice and give nomenclature as this pattern has not found its place in the available classification system. The management of these fractures is challenging including removal of the broken implants and inevitably requiring a revision hip arthroplasty. Similar type of fractures has been reported as case reports but the authors have not made any attempt to classify them [10]. We tried to incorporate this unique fracture type into the existing classification system which we believe, will be a fair to the similar pattern of fractures that has been reported in the literature. This will also help in better understanding and communication of the similar pattern of fractures in future.

Limitations

There are certain limitations in this study. This is a small series of periprosthetic fracture with mixture of cases including unipolar, bipolar and total hip arthroplasties. Also, the possible mechanism of fracture is the stress concentration to a stem where the distal part is well fixed and the proximal part is relatively loose that was described in Charnley's era as well. This may require a comprehensive biomechanical study including the finite element analysis of the broken prostheses to explain the exact mechanism of fracture in each case, which has not been done in this study. However, the main aim of this study was to draw attention to this unique fracture pattern and allocate a potential place in the classification system for better understanding and further studies.

Conclusion

The new pattern of periprosthetic fracture though rare is technically challenging. We have encountered such fractures after hip arthroplasty only. However, we surmise that with

increasing number of arthroplasties done worldwide, the classification type may be encountered in arthroplasties at other sites as well in future and recommend its inclusion in the Universal Classification System (UCS). Including this type in classification will ensure that if this pattern is reported from other joints, it will not have to search for its place in Universal Classification System. Authors hope that this addition will find a place in the algorithm for the reporting and management of periprosthetic fractures and augment the existing Unified Classification System.

Future Directions

The authors welcome the reporting or sharing of periprosthetic fracture of such patterns following joint arthroplasty in any other joints for a multicenter study. We hope this will help in research into the extraction technique and management of such rare and complicated fractures.

Declarations

Conflict of interest The authors declare no conflict of interest.

Ethical approval Ethical clearance was taken from the Institute Ethics Committee before conducting the study.

Informed consent For this type of study informed consent is not required.

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